Identical Particles

Indiscernibility of Identicals

$x = y \to \forall P (Px \leftrightarrow Py)$ 2nd order predicate logic

Identity of Indiscernibles

$\forall P (Px \leftrightarrow Py) \to x = y$. (Leibniz principle.)

~~strong~~ weak version 'P' includes location
~~weak~~ strong 'P' does not include location.

In classical mechanics weak version at least (but not strong version due to impenetrability) is violated we can have 2 atoms of hydrogen. they are indistinguishable and yet numerically distinct (i.e. not identical)

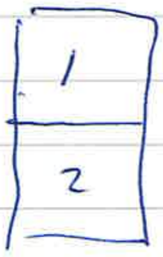
So Identity → Indistinguishability
But Indistinguishability ↛ identity.

There is no doubt in classical mechanics particles are individuals i.e. they are distinct 'things' possessing transcendental individuality – they can be ascribed proper names e.g. John & Jack.

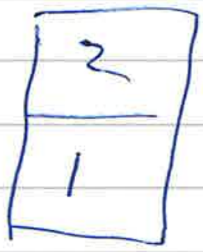
~~Distinguish~~ But can we legitimize proper names i.e. a name – John is the unique object having the property ~~of be~~ John-ness
But how can we ever guarantee uniqueness

exactly by noting its location precisely.

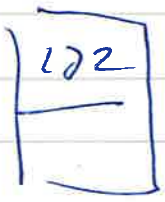
Transcendental individuality is used in the Continental approach to classical stat. mechanics

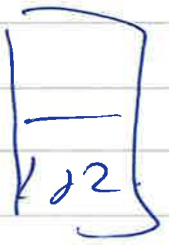
a) 

different complexions

b) 

4 possible states assigned equal weight

c) 

d) 

So chance of finding one particle in each is $\frac{1}{2}$.

But in QM the result for Bose statistics is 1/3

since a) & b) are counted as the same state.

Does this mean that in QM electrons do not possess transcendental individuality?

- they are in some sense non-individuals.

It is often claimed that this is so, that electrons are non-individuals because of the Pauli Principle etc.

We shall show that description in terms of individuals or non-individuals is available both in classical and Q. mechanics

Note An individual (or an entity itself) can be identified (ontologically) as this object rather than that.

A. continuant can be re-identified (ontologically) as the same individual thru time.

Two objects are identical if they are (in virtue of TI) one and the same object.

~~A particle~~ An individuator is that feature of an individual which individuates it

Two objects are indistinguishable if they have all the same properties.

A particle is a continuant (which is individuated by its transcendental individuality) (substratum that bears its properties) and which has a mass and location, which varies with time, but no extension (point particle)

A. field configuration is an individual which is a non-continuant (is an ephemeral) which is individuated by the transcendental individuality of its spatial locations.

When 2 ~~particles~~ indistinguishable particles change places there is ontologically a new state of affairs.

When 2 indistinguishable flips in a field change place.

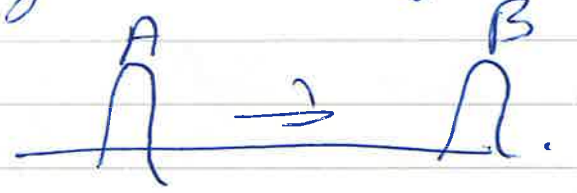
no new state is achieved since

Individual A → Individual B

" B → " A.

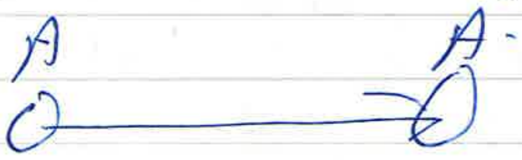
In a field, a probability (that there is a particle here) is being passed from one individual to another (i.e. from one space-time point to another) ie for non-continuants one individual can change into another individual at successive times.

This is what happens when a blip propagates in a field.



Individual A becomes individual B

cf particle propagation.



The same individual moves from one location to another ie. One changes an attribute 'velocity' for another.

N.B. There cannot be more than one identical object.

But there can be 2 or more individuals which are continuants as also 2 or more individuals which are non-continuants.

This raises the question of how we can have a theory of non-individuals (really non-continuants) and possibly have more than one of them.

But note that ephemerals may also be regarded as

relative continuants which can be reidentified through time as the same S, for some sortal predicate S.

In the case of a field blob one can identify a as the same blob as b via spatio-temporal continuity in the development of blob b from blob a

cf you cannot step in the same river twice (Heraclitus).
You can step in the same river, but not the same water

A river is a relative continuant
a piece of water is an (absolute) continuant.

Note that while a field configuration is an ephemeral, a field system may be regarded as the changing states of a set of continuants, the primary individuals, i.e. the space-time 'points'

A process-thing S is a succession of states of affairs involving different continuants but showing some invariant feature S. 'a is the same S as b' is a relative identity statement. A process will be said to persist

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Persistents {
continuants — persistence of matter
re-identifiable ephemerals — persistence of form
↳ process-things

Ex flame, cell, River

Theseus' Ship

process-things exhibit relative identity

'a' is same F as 'b' for sortal predicate S.F.

1986 Summary Individuals are physical particulars

Continuants (particles and places?)
↓
physical things

ephemerals (process stages, instants of time)

Persistent ephemerals (process-things) eg. flames rivers etc. — persistence of form

non-persistent i.e. non re-identifiable ephemerals. like mixed-up waves.

Entities which are individuals but not continuants I shall call ephemerals

Notice that blips in a field are ephemerals even if they do not move if we record: movement of an ephemeral as its destruction at one point and recreation at another point

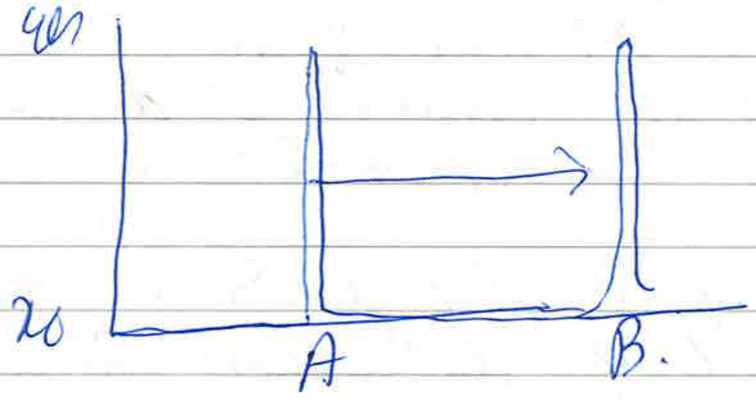
cf. Even if the two points are coincident this mode of description makes sense.

The change of state of an ephemeral is described by an operator $\alpha = \xi\eta$ where η destroys the ephemeral in its original location and ξ recreates it in its new location.

For a continuant α only changes the location of one (fixed number) of particles in its state space.

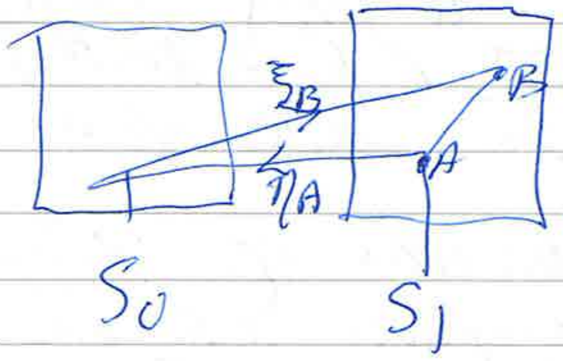
The change in description of change: from a description in terms of continuants to a description in terms of ephemerals corresponds to the change from α to the 'factorized' form $\xi\eta$.

This is just as true in classical mechanics as in quantum theory in the transition from 1st quantization to 2nd quantization



the movement of a 'particle' from A to B
is described by the operators.

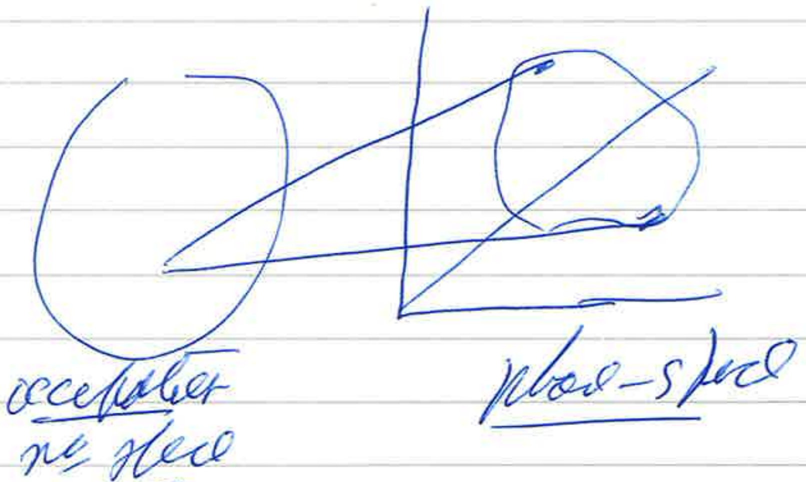
$$Q(A) = B \;=\; \bar{\xi}_B \eta_A$$


ξ_B
η_A
B
A
S_0
S_1

We can describe elementary particles either as continuants or as ephemerals.

But in qft where particles do get created and destroyed the description in terms of ephemerals becomes much more appropriate.

yes/no (dichotomic field) gives description of an ephemeral in terms of occupation no. space. We can introduce labels (index names) e.g. continuants of space-time trajectories in the field description. Then [illegible] how we can get correct counting of states in classical statistical mechanics



cf Discussion of moving regions of impenetrability by Newton in 'On the Gravity & Equilibrium of Fluids' p. 139 ff. in Hall & Hall 'Unpublished Scientific Papers of Isaac Newton'.

quantized field.

N-particle S.Eq. $\xrightarrow[\text{Fock space.}]{}$ 'fields'

1-particle S.Eq. $\xrightarrow[2^{\text{nd}}\ \text{quantization}]{}$ quantized field.

Field system. $\xrightarrow[\text{Field quantization}]{}$ quantized field.